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Medieval window glass in Scotland

Citation for published version:

Spencer, HM & Kennedy, CJ 2017, Medieval window glass in Scotland. in *Annales du 20e Congrès de l'Association Internationale pour l'Histoire du Verre*. AIHV, pp. 672-679, 20^e Congrès de l'Association Internationale pour l'Histoire du Verre, Fribourg, Switzerland, 7/09/15.

Link:

[Link to publication record in Heriot-Watt Research Portal](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

Annales du 20e Congrès de l'Association Internationale pour l'Histoire du Verre

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ANNALES

du 20^e CONGRÈS
de l'ASSOCIATION
INTERNATIONALE
pour l'HISTOIRE du VERRE

Fribourg / Romont 7-11 septembre 2015

This volume is sponsored by Vitrocentre and
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Cover illustration

Goblets with white filigree decoration, produced in Swiss glasshouses, late 17th to early 18th century. From different Swiss public and private collections. For a detailed discussion see: Erwin Baumgartner, *Reflets de Venise*, Bern 2015, p. 254–272, 322–328 and the contribution of Christophe Gerber in the present volume, page 564.

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AIHV

Association Internationale pour l'Histoire du Verre
International Association for the History of Glass
Internationale Vereinigung für die Geschichte des Glases
www.aihv.org

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Romont 2017

Gesamtherstellung



Verlag Marie Leidorf GmbH,
Geschäftsführer: Dr. Bert Wiegler,
Stellerloh 65 · D-32369 Rahden/Westf.
Tel.: +49/(0)5771/9510-74 · Fax: +49/(0)5771/9510-75
E-Mail: info@vml.de
Homepage: www.vml.de
Gedruckt auf alterungsbeständigem Papier
Druck: druckhaus köthen GmbH&Co. KG, Köthen

ISBN 978-3-86757-024-4

CONTENTS

XI	PRÉFACE
XIII	PREFACE
XV	VORWORT
	<i>Sylvia Fünfschilling</i>

ANTIQUE AND ISLAMIC GLASS (KEYNOTES)

2	L'étude du verre antique. Etat de la question <i>Marie-Dominique Nenna</i>
10	Entre Orient et Occident, le verre islamique (VIII ^e –XIII ^e siècle) : apports récents et réflexions sur les échanges et les influences <i>Danièle Foy</i>

ARCHAIC, CLASSICAL AND HELLENISTIC GLASS

36	Glass fragments from Qal'eh Kali, an Achaemenid site in south-western Iran <i>Bernadette McCall, Amanda J. Dusting</i>
43	Capacity measurement to demonstrate standardised productions of the core-formed vessels from the late Archaic to the late Hellenistic period. An interim report <i>Peter Cosyns, Bieke Verhelst, Karin Nys</i>
48	The provenance of Hellenistic core-formed vessels from Satricum, Italy <i>Artemios Oikonomou, Marijke Gnade, Julian Henderson, Simon Chenery, Nikos Zacharias</i>
54	Glass vessels from the Persian and Hellenistic administrative building at Tel Kedesh, Israel <i>Katherine A. Larson, Andrea M. Berlin, Sharon Herbert</i>
61	Gold in glass <i>Despina Ignatiadou</i>
68	A study of the cut gold leaf decoration techniques on ancient gold sandwich glass, with emphasis on the Hellenistic 'Kirikane' technique <i>Hidetoshi Namiki, Yasuko Fuji</i>
73	Hellenistic mosaic glass and La Tène glass-working <i>Natalie Venclová, Šárka Jonášová, Tomáš Vaculovič</i>

ROMAN GLASS

82	Gold-band glass fragments in the Römisch-Germanisches Museum of Cologne: considerations about the techniques <i>Giulia Cesarin</i>
87	La vaisselle en verre de deux sépultures aristocratiques augusto-tibériennes à Ath/Ghislenghien (Province de Hainaut, Belgique) <i>Frédéric Hanut, Véronique Danese</i>
92	Le verre romain de Montignac-sur-Vézère (Dordogne) <i>Laure Simon</i>
98	The Roman necropolis of Budva (Montenegro) and its mould-blown glass assemblage <i>Irena Lazar</i>
103	Mold-blown glass from the Roman province of Dalmatia <i>Berislav Štefanac</i>
109	Römische Tintenfässer Isings 77 <i>Michael Johannes Klein</i>
116	A comparative investigation of the glass vessels and objects from eastern Thrace and Lydian tumuli in the light of the Dügüncülü and Güre finds <i>Ömür Dünya Çakmaklı, Emre Taştemür</i>

- 124 Le sanctuaire d'Yvonand-Mordagne (Vaud, Suisse) : premier aperçu de la vaisselle cultuelle en verre
Chantal Martin Pruvot, Ellinor Stucki
- 132 Blown mosaic glass of the Roman period: technical observations and experiments
E. Marianne Stern
- 140 Two polychrome mosaic bowls and associated glass vessels from a rich 2nd century burial at Kelshall, Hertfordshire, England
Sally Cottam, Jennifer Price
- 145 Früh- und mittelkaiserzeitliche Glasgefäße im nördlichen Obergermanien
Martin Grünewald
- 152 L'exceptionnelle verrerie d'un bûcher funéraire du III^e siècle après J.-C. de Jaunay-Clan (Vienne, France)
Laudine Robin
- 160 Le verre archéologique du Canton du Tessin (Suisse) : une révision
Simonetta Biaggio-Simona
- 163 More glass from Aquileia (Italy)
Luciana Mandruzzato

LATE ROMAN AND EARLY MEDIEVAL

- 168 Mapping glass production in Italy. Looking through the first millenium AD
Barbara Lepri, Lucia Sagui
- 175 Chemical signature and scale of production of primary glass factories around the Mediterranean in the first millenium AD
Patrick Degryse
- 181 The cut-glass beaker from Biel-Mett/BE
Sylvia Fünfschilling
- 184 New evidence about engraved glass from Milan (Italy) (3rd–4th century AD)
Marina Ubaldi
- 190 Besondere Glasfunde aus dem Gräberfeld Gönheim (Kreis Bad Dürkheim) – Germania prima – und ein neuer Ort möglicher Glasverarbeitung
Andrea Ideli
- 194 Glass vessels from Late Roman burials in Languedoc-Roussillon (France): key points, from glass production to the ritual of grave deposits
Stéphanie Raux
- 203 Late antique and early medieval glass vessels from northern-central Apulia: productions, typologies, functions and circulation
Francesca Giannetti, Roberta Giuliani, Maria Turchiano
- 209 A large glass dish from Cástulo (Linares – Jaén, Spain) with an engraved representation of Christ in Majesty
David Expósito Mangas, Marcelo Castro López, Francisco Arias de Haro, José Manuel Pedrosa Luque, Bautista Ceprián del Castillo
- 213 Late Roman glass from Mala Kopašnica (Serbia) – forms and chemical analysis
Sonja Stamenković, Susanne Greiff, Sonngard Hartmann
- 222 Glass vessels from Late Roman graves in the Hungarian part of the Roman province Pannonia
Kata Dévai
- 230 Recent glass finds from Elaiussa Sebaste in Cilicia
Çiğdem Gençler-Güray
- 235 Indices d'ateliers de verriers à Apamée de Syrie, à la fin de l'Antiquité
Danièle Foy, avec la collaboration de Bernard Gratuze
- 240 Une mosaïque de verre à thème chrétien (V^e s.), du site monastique copte des Kellia (Basse-Égypte)
Denis Weidmann
- 243 New finds of mosaic glass inlays from Antinoupolis, Egypt
Flora Silvano

- 248 Glass bead trade in northeast Africa in the Roman period.
A view according to the Museum of Archaeology University of Stavanger assemblage
Joanna Then-Obluska, Barbara Wagner
- 257 A Late Roman glass workshop at Komarov (Middle Dniester) and
the problem of the origin of 'Barbarian' facet cut beakers
Olga Rumyantseva, Constantin Belikov
- 265 The glass collections in the 'Museum Aan de Stroom' (MAS), Antwerp (Belgium)
Eugène Warmenbol, Annemie De Vos, Peter Cosyns
- 271 Le verre de la nécropole mérovingienne de La Mézière (Bretagne, France)
Françoise Labaune-Jean

BYZANTINE AND ISLAMIC GLASS, NEAR EAST

- 280 Opaque red glass tesserae from Roman and early-Byzantine sites of north-eastern Italy:
new light on production technologies
Sarah Maltoni, Alberta Silvestri, Gianmario Molin
- 288 The Early Islamic green lead glass from the excavations at Caesarea Maritima, Israel
Rachel Pollak
- 293 Study on the Early Islamic glass excavated in Paykend in the Bukhara Oasis, Uzbekistan
Yoko Shindo
- 300 Reexamination of a Mamluk glass collection from Jerusalem
Naama Brosh
- 307 Mamluk glass from Quseir al-Qadim: chemical analysis of some glass fragments
Laure Dussubieux
- 313 An outstanding glass assemblage from the medieval and Ottoman castle at Safed (Zefat)
Natalya Katsnelson, with a contribution by Matt Phelps
- 319 Byzantine glass bracelets in Western Rus. Archaeological finds from Belarus
Kristina A. Lavysh

EUROPEAN GLASS FROM 700 TO 1500

- 326 Red and orange high-alumina glass beads in 7th and 8th century Scandinavia:
evidence for long distance trade and local fabrication
Torben Sode, Bernard Gratuze, James W. Lankton
- 334 Evolution of glass recipes during the Early Middle Ages in France:
analytical evidence of multiple solutions adapted to local contexts
Inès Pactat, Magalie Guérit, Laure Simon, Bernard Gratuze, Stéphanie Raux, Céline Aunay
- 341 'The Emerald of Charlemagne': new observations on the production techniques and
provenance of an enigmatic glass artefact
Cordula M. Kessler, Sophie Wolf, Jürg Goll
- 346 Les verres du Haut Moyen Âge issus des fouilles du *monasterium Habendum* (Saint-Amé, Vosges)
Hubert Cabart (†), Inès Pactat, Bernard Gratuze, avec la collaboration de Charles Kraemer et Thomas Chenal
- 354 Technological transition in early medieval northern Italy: preliminary data for Comacchio glass
Camilla Bertini, Julian Henderson, Sauro Gelichi, Elena Basso, Maria Pia Riccardi, Margherita Ferri
- 360 Where does the medieval glass from San Genesio (Pisa, Italy) come from?
Marja Mendera, Federico Cantini, Alessandra Marcante, Alberta Silvestri, Filomena Gallo, Gianmario Molin, Marco Pescarin Volpato
- 366 Natron and plant ash glass in the Middle Danube region during the Early Middle Ages
Danica Staššíková-Štukovská
- 374 Glass in fashion and trade in Bohemia in the 9th-11th century (archaeology and archaeometry)
Kateřina Tomková, Šárka Jonášová, Zuzana Zlámalová Cílová

- 379 13th–14th century glass in northwest Bohemia: typology, archaeometry and provenance
Eva Černá
- 385 Glass production in medieval Spain: a long-term perspective on knowledge transfer
Chloë N. Duckworth
- 391 Die Glaserzeugnisse Bolgars und ihr Verhältnis zu anderen mittelalterlichen Glasproduktionen
Svetlana Valiulina
- 399 Glass from Enez (ancient Ainos)
Üzlifat Canav-Özgümüş, Serra Kanyak
- 403 Indices de travail du verre rouge dans l’atelier médiéval d’Anlier, seconde moitié du XIV^e siècle (Luxembourg belge)
Chantal Fontaine-Hodiamont, Denis Henrotay

EUROPEAN GLASS FROM 1500 TO 2000

- 412 Looking through late medieval and early modern glass in Portugal
Teresa Medici, Inês Coutinho, Luís C. Alves, Bernard Gratuze, Márcia Vilarigues
- 421 La consommation du verre à Paris entre le XIV^e et le XIX^e siècle : des données récentes
Amélie A. Berthon, Isabelle Caillot, Kateline Ducat
- 429 Zur Frage der Provenienz von historischen Gläsern – Die Sammlung des Herzog Anton Ulrich-Museums in Braunschweig und des Rijksmuseums Amsterdam
Nicole Brüderle-Krug
- 435 Les verres émaillés vénitiens de la Renaissance : le projet Cristallo
Françoise Barbe, Fernando Filipponi
- 444 Renaissance Venetian enamelled glass. Genuine, façon de Venise and fake or copy artefacts
Marco Verità, Isabelle Biron
- 453 All-glass hybrids: Why they were made and the importance of identifying them
Suzanne Higgott
- 460 All-glass hybrids: What they are, manufacturing techniques and detection
Juanita Navarro
- 467 Venedig oder Tirol? Zur Lokalisierung einiger Hohlgläser des 16. Jahrhunderts mit Kaltbemalung im Bayerischen Nationalmuseum
Annette Schommers
- 474 Glashütte Hall in Tirol. Die archäologischen Grabungen 2008 und 2009
Anna Awad
- 482 Goblets of the late- to post-medieval period from archaeological excavations in Dubrovnik
Nikolina Topić
- 490 16th-century glass vessels from the burials of the Ascension Convent in the Moscow Kremlin
Ekaterina Stolyarova
- 495 The problem of forgeries in 19th century Murano
Aldo Bova
- 498 Deutsche Formgläser des 16. und 17. Jahrhunderts? Beobachtungen und Überlegungen zu einer Neudatierung
Dieter Schaich
- 506 Die älteren Glashütten der Schweiz (ca. 1200–1800)
Walter Schaffner
- 512 „À la façon de Venise“: Zur Geschichte des Begriffs und zur Verbreitung von Gläsern in venezianischer Art in Westfalen
Sveva Gai
- 522 Haushalt, Apotheke oder Gasthaus? Zusammensetzungen frühneuzeitlicher Glasfundkomplexe im Kontext ihrer Fundsituation
Birgit Kulessa

- 532 Mirrors, spectacles and looking glasses in Antwerp and the Duchy of Brabant: aspects of production and use of optical glass based on serial documentary and archaeological evidence
Danielle Caluwé
- 537 *Façon de Venise*, une étiquette problématique. Propositions pour une méthodologie raisonnée de l'étude de la verrerie à l'italienne en Europe, XV^e-XVIII^e siècle, à partir de l'exemple du marché parisien (1550-1665)
Benoît Painchart, Christiane Guyomar
- 542 Diagnostic differences between early filigree glass and the Rosenborg Castle-type filigree glass
Kitty Laméris
- 547 The golden age of Amsterdam glass. A chemical and typological approach to recognize Amsterdam 17th century glass production
Michel Hulst, Jerzy J. Kunicki-Goldfinger
- 554 What's the purpose: oil lamp, perfume sprinkler or trick-glass?
Reino Liefkes
- 561 Court, Pâturage de l'Envers : une verrerie forestière du début du XVIII^e siècle entre tradition et modernité (Jura bernois, Suisse)
Christophe Gerber
- 567 Der Kühlprozess der Glashütte von Court, Pâturage de l'Envers (1699-1714) im Berner Jura (Schweiz)
Jonathan Frey
- 575 Quelques révélations sur l'outillage de la verrerie du Pâturage de l'Envers à Court (1699-1714)
Lara Tremblay
- 578 Eighteenth century lead glass in the Netherlands
Anna Laméris
- 585 Imported beads in Russia in the 17th and first half of the 18th centuries (Moscow, Mangazeya, Smolensk region)
Julia Likhter
- 591 „Pressglas“ aus Benedict Vivats Glasfabriken
Valentina Bevc Varl
- 597 Glass fishing floats from Greek sites
Anastassios Antonaras
- 602 Crizzling glass – corrosion products and chemical composition of Bohemian glass
Zuzana Zlámálová Cílová, Helena Brožková, Michaela Kněžů Knížová, Irena Kučerová
- 606 The development of the chemical composition of Czech mosaic glass from the Middle Ages to the present day
Michaela Kněžů Knížová, Zuzana Zlámálová Cílová, Irena Kučerová, Martin Zlámál
- 612 The glass collection of Felice Barnabei at the Museo Nazionale Romano – Palazzo Massimo in Rome
Giulia Giovanetti, Silvia Bruni
- 617 Zwei vernachlässigte Glasvarietäten des 19. Jahrhunderts: Aventurin-Hohlglas und Uran-Selenglas
Sibylle Jargstorf
- 621 The Glass Room of the National Palace of Necessidades in Lisbon
Alexandra Rodrigues, Bruno Martinho, Frederik Berger, Anísio Franco, Márcia Vilarigues
- 625 Albert Dammouse (1848-1926) et la pâte de verre (1897-1913)
Véronique Ayroles
- 631 Le verre artistique de Saint-Prex (1928-1964)
Stanislas Anthonioz, Ana Quintero Pérez

ASIAN GLASS

- 640 A unique glass object from a Buddhist context in Sri Lanka
Brigitte Borell
- 647 Glass exchange and people in ancient East Asia
Chizuko Kotera

- 652 Glass from Mughal India. A study of four eighteenth century cobalt blue bottles
Tara Desjardins

WINDOW GLASS AND STAINED GLASS

- 660 The early medieval stained glass windows from St. John, Müstair: materials, provenance and production technology
Sophie Wolf, Cordula M. Kessler, Jürg Goll, Stefan Trümpler, Patrick Degryse
- 668 Painted window glasses from Akko/Acre from the Crusader period (1099–1291 CE).
Manufacturing processes and conservation
Adrienne Ganor
- 672 Medieval window glass in Scotland
Helen Spencer, Craig Kennedy
- 680 Untersuchungen zur Provenienz von Gläsern aus dem Kloster Maulbronn
Manfred Torge
- 684 Swiss *Kabinettscheiben* from a 19th century Portuguese collection. Study and chemical characterisation
Andreia Machado, Alexandra Rodrigues, Mathilda Coutinho, Luís C. Alves, Victoria Corregidor, Rui C. da Silva, Vincent Serneels, Ildiko Katona Serneels, Sophie Wolf, Stefan Trümpler, Márcia Vilarigues
- 689 Le vitrail dans les hôtels suisses de la Belle-Epoque : une importance sous-estimée ?
Dave Lüthi
- 697 „Magisches Licht“ – Glasfenster in der neo-islamischen Architektur
Sarah Keller
- 699 The window glass and stained glass windows of Belém: a cultural history of the Brazilian Amazon region
Amanda Corrêa Pinto, Márcia Vilarigues, Thais Sanjad
- 703 Autour d'un artiste-verrier de la première moitié du XX^e siècle.
Marcel Poncet (1894-1953) : à la jonction de la peinture et du vitrail
Camille Noverraz
- 706 L'activité créatrice de Paule Ingrand au sein d'« Art et Verre » (1946 à 1962)
Isabelle Lecocq, avec la collaboration de Catherine Thomas
- 713 Makellos transparent oder mit romantischen Schlieren? Überlegungen zu Sortenvielfalt und Ästhetik des
Fensterglases im frühen 20. Jahrhundert mit Fokus auf dem Spiegel- oder Kristallglas
Anne Krauter, Ueli Fritz

REVERSE PAINTING ON GLASS

- 722 Une œuvre du Vitromusée Romont passée à la loupe. Un cabinet de facture napolitaine décoré de plaquettes
de verre peintes
Elisa Ambrosio
- 725 La peinture sous verre « savante » en France au XVIII^e siècle : oubliée puis redécouverte
Jeannine Geyssant
- 732 La peinture sous verre chinoise au XVIII^e siècle. Une rencontre artistique Chine – Occident
Thierry Audric
- 735 La peinture sous verre monumentale de l'église paroissiale de Mézières (Fribourg, Suisse) :
« La délivrance de Saint Pierre », 1940, par Emilio Maria Beretta
Monika Neuner, Yves Jolidon, Pascal Moret

GENERAL THEMES

- 740 Le verre à l'école, un projet pour les jeunes
Maria Grazia Diani, Luciana Mandruzzato

MEDIEVAL WINDOW GLASS IN SCOTLAND

Helen Spencer, Craig Kennedy

When compared to other parts of Europe, Scotland has a lack of both documentary and artefactual evidence for the use, working and manufacture of glass. There is no undisputed evidence for glass manufacture from its raw materials in Scotland until 1610, when the first patents for glass manufacture were issued.¹ The earliest excavated glass furnace, in which glass was directly made from its raw materials, is situated at Morison's Haven, East Lothian² and is dated to the late 17th–early 18th century. Centres of industrialised glass manufacture are known to have existed in England and Ireland in the later medieval and post-medieval periods.

It may be considered unusual that there was no attempt to produce glass in Scotland in the medieval period, when abundant raw materials were available in the region to make glass in the Northern European medieval glass-making tradition. However on the Northern fringes of Europe other countries show no evidence of a manufacturing glass industry until the post-medieval period – for example Finland, where there is no evidence of glass production until 1681.³

Scottish window glass from the medieval and post-medieval periods is being studied by a Research team at Heriot Watt University, Edinburgh. The research focuses on the scientific analysis of the composition of window glass – both archaeologically excavated fragments and in-situ panes from post-medieval and industrial buildings. The research into the scientific analysis of medieval window glass will aim to answer questions such as where was the glass manufactured, such as which trade routes brought glass into Scotland and where the craftsmen who worked on glazing Scottish buildings came from. Whilst research has taken place accounting for these factors from 1610 onwards,⁴ very little research has taken place focusing on the pre-1610 era.

WINDOW GLASS IN SCOTLAND PRIOR TO 1000 AD

Glass beads from the Iron Age are the earliest evidence of the use of glass in Scotland. The discovery of the Iron Age industrial site of Culduthel in Inverness-shire has provided evidence of low-temperature glass working, primarily the making of beads in a local style but using an imported, heavily recycled natron glass.⁵

The earliest evidence for windows and glazing come from Roman buildings – particularly military lodgings along the line of the Antonine Wall such as at Crawford Roman fort in Lanarkshire, Falkirk⁶ and civilian buildings such those at Inveresk in East Lothian⁷. So far no evidence

has been found to show these window panes were made in Scotland, nor have any Roman glass-working sites been discovered in Scotland.

There is a gap in evidence for glazing until the earliest medieval Scottish window glass fragments, which have been found in excavations at the Whithorn monastic settlement in Dumfries and Galloway.⁸ 132 sherds are associated with an 8th–9th century chapel building which was thought to be a timber building. The completed windows may have been made elsewhere and then transported to Whithorn in their wooden frames, or the flat glass may have been brought to site and then made into windows. Scientific analysis found the glass to be predominantly of natron glass although it may have been partially adulterated with plant ash glass as some fragments have a composition lying midway between a typical natron and sodic plant ash. The glass was very similar in chemical composition to that found at Jarrow and Monkwearmouth in North-East England. As well as window glass, numerous glass vessels have also been found at Whithorn and one author has suggested that some of these vessels may have been made in Scotland. Campbell⁹ identifies a vessel Group 'E' that he suggests may represent production in Scotland by continental glass makers. They have a typology unique to the site and may represent a local attempt to imitate imported goods for a short period during the 6th century. If this is the case, could the same glass makers also have made the window glass on site?

Other Scottish early medieval sites, including Iona and Dunadd, have also yielded glass finds and potential evidence of glass working, including bi-chrome glass rods, possible cullet and moulds, but no evidence of window glass.¹⁰

A crucible containing glass working residue was found in a small industrial complex at the 8th century Pictish monastic site at Portmahomack, Tarbet Ness.¹¹ This opaque yellow glass waste was found to be a soda-rich glass, coloured

1 TURNBULL 2001, 1.

2 CRESSEY et al. 2012, 36.

3 KUISMA-KURSULA and RAISANEN 1999, 72.

4 KENNEDY et al. 2013, 465.

5 BERTINI et al. 2014, 256.

6 KEEPIE and MURRAY 1981, 248.

7 THOMAS 1988, 158.

8 CRAMP 1997, 327.

9 CAMPBELL 2007, 73.

10 LANE and CAMPBELL 2000, 174.

11 PEAKE and FREESTONE 2011, 18.

and opacified with the addition of lead antimonite. The small crucible and the limited amount of glass residue found within an area of more general metalworking suggest the glass made would have been used as decorative enamel work. The buildings on the site at this period were thought to still be made of timber and there is no evidence that vessels or window glass were produced.

There has so far been no evidence for larger-scale glass working in Scotland during this period – such as that found at Glastonbury Abbey in England, where four furnaces and a large amount of glass working waste were excavated in the 1950's but more recently associated with the founding of the Abbey in the late 7th century.¹²

MEDIEVAL WINDOW GLASS

Across Europe there are numerous examples of in situ stained glass windows in churches and cathedral buildings, however in Scotland virtually no in situ window glass survives from before the post-medieval period. Almost all the glass windows in ecclesiastical or monastic buildings were destroyed before, during or shortly after the Reformation in 1560. The trappings of the Catholic Faith were considered iconoclastic and in a short space of time churches and monastic buildings were stripped, despite the First Book of Discipline specifying that the windows of religious buildings should not be destroyed and remain glazed.¹³ Some windows survived the initial destruction, such as the stained glass in King's College Chapel in Aberdeen, which survived into the 17th century. However, the lead comes and glass cullet would have been valuable commodities and were soon stripped and removed from most buildings. At Elgin Cathedral there is evidence of lead-smelting activity in the years following the Reformation, which probably included recycling the lead comes.

The earliest 'in situ' pieces of late medieval window glass known to survive are two small heraldic panes depicting the coat of arms of Mary of Guise, thought to have been made between 1541 and 1547 and installed in Magdalen Chapel, Edinburgh (figure 1). A few fragments of pre-reformation window glass were incorporated into two modern pointed windows, now in the coffee shop in the crypt of St Giles Cathedral, Edinburgh. There is also reference to an early 20th century panel made from fragments of medieval stained glass originally found at Holyrood Abbey which was created to be put on display in Holyrood Palace.¹⁴ This has recently been located in the stores of the Royal Collection.

For a number of reasons glass from the medieval period is found in lower quantities in excavations in Scotland compared to the rest of the United Kingdom. It is probable that glass was less common in Scotland, certainly in a domestic context. Even high-status buildings such as the Scottish Tower Houses have little evidence of being glazed until the late 15th century and in most cases much later. Glass found from this period is heavily corroded; the surfaces have been leached of lighter alkali ions and have been replaced with insoluble black crusts. The highly acidic burial conditions



Fig. 1: 'Arms of Mary of Guise, Magdalen Chapel, Edinburgh'
© Kim Traynor – Own work. Licensed under CC BY-SA 3.0 via Commons – https://commons.wikimedia.org/wiki/File:Arms_of_Mary_of_Guise,_Magdalen_Chapel,_Edinburgh.JPG#/media/File:Arms_of_Mary_of_Guise,_Magdalen_Chapel,_Edinburgh.JPG.

in many regions of the country accelerate decay, combined with the original chemical composition of this type of glass, resulting in poor preservation.

The last major study and catalogue of medieval stained window glass in Scotland was carried out by Dr Pam Graves in 1985, who identified 18 sites where glass had been found. Since then further excavations, such as at Inchaffray Abbey,¹⁵ Pluscarden Priory,¹⁶ Elcho Nunnery¹⁷ and Perth City Centre¹⁸ have uncovered significant assemblages. In addition, reassessments of the window glass assemblages found at Elgin¹⁹ and nearby Spynie Palace²⁰ have been carried out. A project to catalogue the window glass assemblage from St Andrew's Cathedral is ongoing at Historic Environment Scotland.

The majority of the medieval glass found in Scotland has been dated to the 13th century. The majority of the glass is 'white' – colourless glass with a smaller percentage of coloured pot metal glass. A minority of the glass is painted with 'grisaille' decoration comprising mainly foliate patterns, geometric borders and cross hatching (figure 2). Graves²¹ noted that Coldingham Abbey was the only Scottish site that had yielded a recognisable glass fragment with a painted figure. This is unusual when considered alongside the large figurative stained glass windows still present in

¹² WILLMOTT and WELHAM 2013, 82.

¹³ SPICER 2003, 32.

¹⁴ EELES 1915, 81.

¹⁵ EWART 1996, 469–516.

¹⁶ MCCORMICK 1994, 391–432.

¹⁷ REID 1988, 68.

¹⁸ BOWLER et al. 1995, 917–99.

¹⁹ MURDOCH 2013, 1–16.

²⁰ GRAVES 2002, 132–137.

²¹ GRAVES 1985, 153.



Fig. 2: Glass fragments found at Elgin Cathedral showing the grisaille decoration. © Robin Murdoch.

most of the great English and European cathedrals. Dating of glass by typological styles is based on English and French dated windows that remain in situ, and it is possible that the development of window decoration in Scotland may not have followed the same trajectory. Graves believed that many of the Scottish fragments exhibited both French and English characteristics with some motifs such as a double trefoil and fine cross hatching are possibly unique to Scotland. At Melrose, there are three distinct styles, one reminiscent of French flamboyant tracery, one of English perpendicular tracery and a style that Graves²² suggests is native Scottish work. The mechanics and procedures of making windows would lead to the assumption that glass painters were at work in Scotland. Even though there is no physical evidence of this, the identification of unique stylistic qualities would support this conclusion.

Many new religious houses were established in the 12th and 13th Centuries. The East Coast ports of Aberdeen, Perth, Dundee and Leith all traded extensively with Europe – particularly Bruges and Flanders, Artois and Picardy, and these routes would have been the most likely for glass importation. There is therefore ample evidence for trade with other European countries where glass production was well established at this point. However, no documentary record of glass importation has been found so far.

The number of large cathedrals and monasteries being built simultaneously across Scotland would suggest that master glaziers and their apprentices, who cut and painted the glass, must have been working extensively in Scotland, but unfortunately little evidence of this remains.

The earliest documentary reference to window glass being produced in Scotland is that glass for the 13th century Dornoch Cathedral was made at Sideray – about two miles from Dornoch.²³ This is taken to mean that imported flat glass was cut, painted and fitted into framework for the windows, rather than the glass itself being made on site. The See of Moray records that ‘Richard’ the glazier was employed at Elgin cathedral in 1237, while at nearby Spynie Palace there is reference to a window being installed in an extension in the mid-13th century, by the glaziers employed to glaze Elgin Cathedral at the time in St Andrews, writing on the tomb of a person named ‘Gray’ records he was a ‘vitriarius’ of the metropolitan church in St Andrews and in Ayr, a Friar called John Strand, who died in 1517, was described as a ‘vitrifaber’ and recorded as working for the Greyfriars around Scotland – including at Perth, Ayr, and Elgin.²⁴

LATE MEDIEVAL PERIOD

The economic boom in the 12th and 13th centuries gave way to a much more unstable economy in the 14th century. The conflict with England led to the seaways being blockaded and the potential for trade diminished. Glass was maybe not as important a commodity in times of war and unrest. Very little ecclesiastical window glass from the later period is found in the archaeological record although window glass found at St Andrews and Dunfermline is likely to be dated to the early 14th century.²⁵

An account written by the Customers of Linlithgow in the Exchequer Rolls for Scotland records that glass for windows was given to the Abbey of Paisley, by Robert II around 1371–1390. There is also a record that it was a Hanseatic merchant who brought ‘the best master of stained glass windows in the world’ from Lubeck [Northern German port] perhaps to glaze James I Charterhouse at Perth but the Florentines were extremely anxious to have him return to his native Italy to work on their Cathedral in 1438.²⁶

It is possible that every large-scale ecclesiastical or monastic stone building would have been glazed at some point during its life. However, evidence suggests that Roslyn Chapel in Mid Lothian, despite being constructed 1446–86, was not fully glazed until 1736.²⁷ The building, notable for its complex iconographic and decorative stone carvings and design, has stonework around the windows that suggests glass was originally destined to be installed but whether due to the cost of the glass, difficulty in obtaining the glass or glaziers, or a change in design this was not completed until centuries later.

²² Ibid, 177.

²³ GRAVES 2002, 132.

²⁴ GRAVES 1985, 149.

²⁵ Ibid, 181.

²⁶ CALDWELL 2015, pers. Comm.

²⁷ BAMBROUGH 2006, 18.



DOMESTIC WINDOW GLASS

There is little evidence for domestic use of glazed windows in the medieval period. Excavations in the city of Perth for example have uncovered a small amount of window glass from middens and it is presumed that it came from ecclesiastical buildings, possibly the nearby Dominican Friary, but cannot be confidently associated with any building.²⁸ One piece of glass from Mill Street excavations, Perth, is the remains of a bullseye. This is from a context dated to no later than 1350, but probably late 13th century, and is evidence that glass is at least being cut from sheets in Perth at this date.²⁹

Window glass fragments have been found at a number of late medieval castle sites. Fragments from Fast Castle from a context dated to the latter quarter of the 15th century were analysed and found to be of forest glass composition.³⁰ Glass of the 'forest composition' has also been found in recent excavations at the late medieval Palace site of Fetternear, suggestive of being made in the early 16th century,³¹ and from Cromarty Castle³² that is likely to have been made in the mid-late 16th century.

The earliest documentary records of domestic window glass being installed in Scotland come from 1550, recording glass windows being installed in a toll booth in Ayr on the West Coast, although part of the glazing is recorded as being glass panes being 'reused from other buildings'.³³

Further work is ongoing, as part of this research project, to analyse late medieval and post-medieval window glass from Scottish domestic contexts³⁴ and compare the development of glass recipes in Scotland with the chronology established for English glass.³⁵

SCIENTIFIC ANALYSIS OF SCOTTISH MEDIEVAL WINDOW GLASS

As outlined above the current evidence suggests window glass was imported to Scotland and then cut and decorated locally by craftsmen, before the final installation. However, this has not been corroborated scientifically.

Chemical analysis can quantitatively or semi-quantitatively identify the concentration of the main and trace elements in the glass. These results can be interpreted to provide information about the raw materials the glass was made from and the technologies used to make the glass. The aim of the current research is to chemically determine the composition of Scottish window glass from a wide range of sites. The results can then be compared with similar scientific studies of glass from England and Europe. It is hoped to identify similarities and differences in glass compositions and use this information to inform our knowledge of where and how window glass used in Scotland came to be made. For example, regional and chronological differences in glass composition in France and Germany have been identified chemically and researchers have therefore been able to differentiate between locally produced and imported glass.³⁶

²⁸ HUNTER 2011, 120.

²⁹ BOWLER et al. 1995, 970.

³⁰ MITCHELL et al. 2001, 84.

³¹ MURDOCH 2008, 55.

³² MURDOCH 2015, 3.

³³ TURNBULL 2001, 53.

³⁴ KENNEDY et al. 2013, 465–78.

³⁵ DUNGWORTH 2012, 192–7.

³⁶ BRILL and PONGRACZ 2004, 125; WEDEPOHL and SIMON 2010, 68.



Fig. 4: Elgin Cathedral. © authors.

Only a limited number of medieval glass window sherds have been subjected to scientific study in Scotland. Longworth and others³⁷ analysed five samples of glass from Elgin Cathedral using Mössbauer Spectroscopy. Tennent and others³⁸ reported on the analysis of twelve samples of glass from Elgin and St Andrews Cathedral by atomic absorption spectroscopy. Work was also undertaken at the National Museum of Scotland to analyse a total of eleven glass fragments from six sites by X-ray fluorescence in the 1980's, which are reported on in Graves.³⁹

The analysis has shown that the glass, as expected, is of potassium-rich 'forest glass' composition. Rauret and others⁴⁰ included the analysis by Tennent and others in their data set used to perform statistical cluster analysis on elemental data comparing the twelve Scottish glass samples with 32 others from Spain, France, Germany and England. This showed that while assemblages from sites such as York, Ulm and Avignon form well separated groups, the Scottish compositions are distributed, suggesting that glass came from a wider range of sources. However, compared to England and the rest of Europe this is only a small sample and there is no published work on trace element or isotopic studies, and the need for study in this area is highlighted in the Scottish Archaeological Research Framework.

Assemblages of medieval window glass fragments have been identified and sampled from a range of sites across Scotland. Figure 3 shows all the sites identified where medieval window glass has been found. Sites highlighted are those where glass has so far been sampled for analysis.

The aim is to characterise the major and minor elements using a combination of scanning electron microscopy and energy dispersive X-ray fluorescence analysis (SEM-EDS) complemented by portable X-ray fluorescence (p-XRF) analysis which enables the analysis of heavier atomic elements.

ELGIN CATHEDRAL – PILOT STUDY

Initial analysis has so far been completed on an assemblage from Elgin Cathedral (figure 4).

Elgin Cathedral is a historic ruin in Elgin, Moray in north-east Scotland. A cathedral was first built on the present site in 1224 with an extensive rebuilding programme following a fire in 1270 and again in 1390. The cathedral was abandoned following the reformation and the roof removed in 1567 following which the cathedral fell into decay.⁴¹ A large assemblage of 1,295 shards of glass is held in the collections of Elgin Museum were excavated in the mid 1970's and in 1996.

Thirty one samples for analysis were chosen to be a representative mixture of colour and shape, as well as having sufficient heart glass remaining for analysis. Analysis was carried out by p-XRF and SEM-EDS following the procedure by Kennedy and others.⁴² The full details and results of the analysis will be published in a future paper.⁴³

As expected all the samples are potash-lime-silica 'forest glass' composition. Potassium levels range from 11–20 wt.% K₂O, while calcium ranges from 12–28 wt.% CaO. Most samples had between 1–3 wt.% of sodium (Na₂O) present, 5–8 wt.% of magnesium (MgO) and 1–3 wt.% of aluminium (Al₂O₃). This is broadly consistent with work by others analysing European medieval glass and the composition is consistent with the typological dating of the 13th century.⁴⁴ Glass rich in potassium generally suggests a medieval glass composition from central continental Europe, and France or Germany would naturally be considered as potential origins of the glass.

A plot of CaO:K₂O ratios (figure 5) suggests that the samples can be separated into two groups and there is a clustering of colours within these groups. The majority of the samples have a CaO:K₂O ratio of between 0.8–1.5. This is consistent with a group of glass identified as Type III by Brill and Pongracz⁴⁵, which they suggest is a compositional type found in both English and French contexts from 1200–1400.

A smaller group has a CaO:K₂O ratio which is greater than 2. This suggests a 'wood-ash-lime' type of glass which is more typical of a German composition or possibly a

³⁷ LONGWORTH et al. 1982, 261.

³⁸ TENNENT et al. 1984, 133–50.

³⁹ GRAVES 1985, 133.

⁴⁰ RAURET et al. 1987, 249.

⁴¹ FAWCETT 2001, 6.

⁴² KENNEDY et al. 2013, 467.

⁴³ SPENCER et al. forthcoming.

⁴⁴ BRILL and WEINTRAUB 1992, 143–8; BRILL and PONGRACZ 2004, 115–44; WEDEPOHL and SIMON 2010, 89–97.

⁴⁵ BRILL and PONGRACZ 2004, 119.

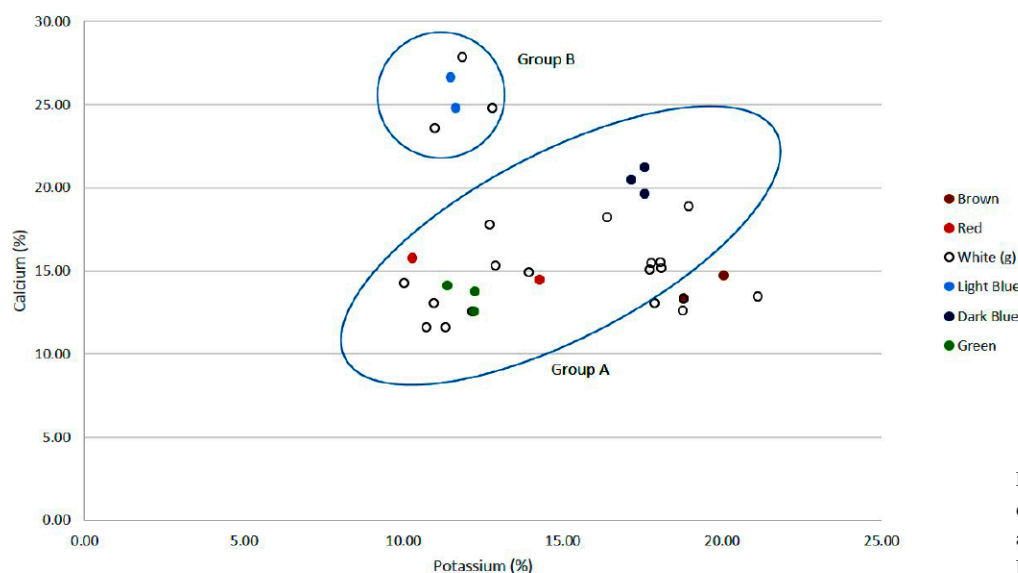


Fig. 5: Plot of potassium vs calcium for 31 glass fragments analysed by SEM-EDX from Elgin Cathedral. © author.

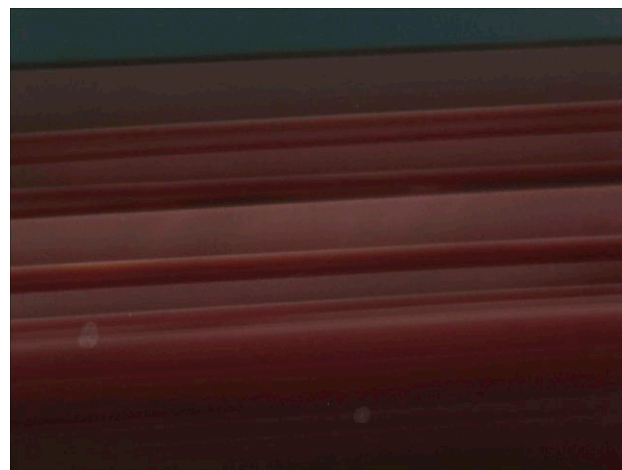
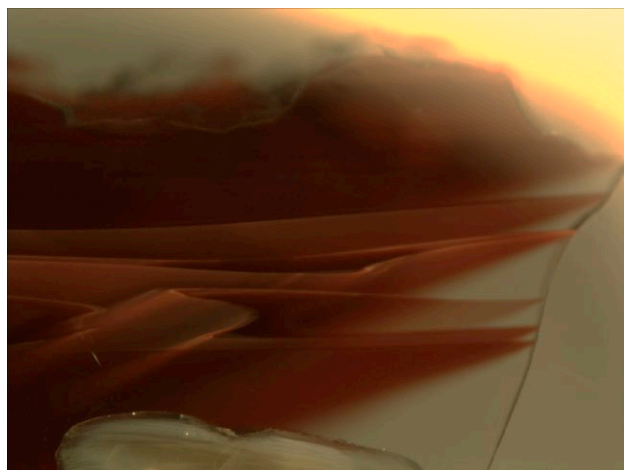


Fig. 6: Cross section of a sample of red glass from Elgin Cathedral showing the multi-layered red and white glass. © author.

French composition but made at a later date than the previous group.

A third possible group, includes the two fragments of brown glass. The two brown glass shards both have lower calcium and a much higher proportion of potassium compared to the other samples, having a $\text{CaO}:\text{K}_2\text{O}$ ratio of only 0.7. The two brown glasses were also notable for their high concentration of phosphorous (>5 wt.% P_2O_5) and magnesium (5–7 wt.% MgO). This may suggest a French origin rather than a German one,⁴⁶ as glass from English and French sources often contained a greater proportion of phosphorous and magnesium than wood ash glass produced in Germany, due to the use of fern and bracken as the main alkali source.

The red glass falls into the first group with a $\text{CaO}:\text{K}_2\text{O}$ ratio of 1.2 and with copper as the main colouring agent being present at 0.46 wt.%. When studied under an optical microscope (figure 6) it can be seen that the red glass is made from a series of striated glass layers according to the description of Spitzer-Aronson and Kunicki-Goldfinger and others.⁴⁷ 'Flashed' glass, where a single (or sometimes double) layer of red glass is on top of a clear sheet, is thought to

have been in use from the late 14th century so the use of the multi-layered glass again suggests an earlier date. The predominant colouring agent of the dark/mid green glass is also copper, being present in concentrations between 3.96–4.97 wt.% CuO .

There are two different blue glass compositions present at Elgin. Two samples have a $\text{CaO}:\text{K}_2\text{O}$ ratio of 1.2 and have around 0.12 wt.% cobalt (CoO) as a main colouring agent. Three other samples are lighter in colour and have less than half the amount of copper compared to the first group. This second group also has a much higher $\text{CaO}:\text{K}_2\text{O}$ ratio of 2.5 and lower levels of magnesium and phosphorous. The difference in these two groups of blue glasses suggests they were made in different locations, possibly at different times. It may be that contrasting tones of blue were sourced from different specialist production centres when the windows were first installed, or that one blue represents a later repair or new window.

⁴⁶ WEDEPOHL and SIMON 2010, 96.

⁴⁷ SPITZER-ARONSON 1986, 672; KUNICKI-GOLDFINGER et al. 2014, 66.

CONCLUSIONS

This paper has presented the start of a multidisciplinary research project to scientifically analyse Scottish medieval and post-medieval window glass. The initial results from the analysis of glass from Elgin Cathedral suggest that glass was imported from a number of different manufacturing locations in Europe in the 13th century, with different colours made in different locations.

Analysis is underway on nearly 200 samples of glass from twelve sites across Scotland using SEM-EDX. It is then planned to carry out trace element analysis using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Trace element analysis will be essential to be able to confirm differences observed in the main element compositions and some trace element concentrations are specific to the original raw materials of sand, alkali, lime and colourants.

The project on medieval ecclesiastical and monastic glass is being complemented by similar scientific research on window glass from late and post-medieval domestic sites.

ACKNOWLEDGEMENTS

We would like to thank Historic Environment Scotland, Elgin Museum and National Museums Scotland for providing access to the collections and for permission to sample for analysis. We would also like to thank Robin Murdoch for his advice and Dr. Jim Buckman for assistance with the analysis.

REFERENCES

BAMBROUGH, Mark, 2006. 'Rosslyn Chapel: A Glazing History', *The Journal of Stained Glass* 30, 12–29.

BERTINI, Martina, MOKSO, Rajmund and KRUPP, Eva M., 2014. 'Unwinding the Spiral: Discovering the manufacturing method of Iron Age Scottish Glass Beads', *Journal of Archaeological Science* 43, 256–266.

BOWLER, David, COX, Adrian and SMITH, Catherine, 1995. 'Four Excavations in Perth', *Proceedings of the Society of Antiquaries of Scotland* 125, 917–999.

BRILL, Robert H. and WEINTRAUB, Steven, 1992. 'Chemical analyses of some stained glass windows in Leon Cathedral'. In: DURÁN, Alicia (ed.), *Proceedings of the XVIth International Congress on Glass*. Boletín de la Sociedad Española de Cerámica y Vidrio ; 31-C. Madrid, 143–8.

BRILL, Robert H. and PONGRACZ, Patricia, 2004. 'Stained Glass from Saint-Jean-des-Vignes (Soissons) and Comparisons with Glass from other Medieval sites', *Journal of Glass Studies* 46, 115–44.

CALDWELL, David, 2015. *personal communication*.

CAMPBELL, Ewan, 2007. *Continental and Mediterranean Imports to Atlantic Britain and Ireland, AD 400–800*. York.

CRAMP, Rosemary, 1997. 'The Early Medieval Window Glass'. In: HILL, Peter and CAMPBELL, Ewan (eds.), *Whithorn and St Ninian: The excavation of a Monastic Town 1984–91*. Stroud.

CRESSEY, Michael, JOHNSON, Melanie, HAGGARTY, George,

TURNBULL, Jill and WILLMOTT, Hugh, 2012. 'Eighteenth-century glass and pottery manufacture at Morison's Haven, Prestongrange, East Lothian', *Post-Medieval Archaeology* 46, 36–55.

DUNGWORTH, David, 2012. 'Historic Windows: Investigation of composition groups with nondestructive pXRF', *European Journal of Glass Science and Technology Part A*, 53.

EELES, Frances. C., 1915. 'Medieval Stained Glass recently recovered from the ruins of Holyrood Abbey Church', *Proceedings of the Society of Antiquaries of Scotland* 49, 81–87.

EWART, Gordon, 1996. 'Inchaffray Abbey, Perth & Kinross: Excavation and research 1987', *Proceedings of the Society of Antiquaries of Scotland* 126, 469–516.

FAWCETT, Richard, 2001. *Elgin Cathedral*. Edinburgh.

GRAVES, C. Pamela, 1985. *Scottish Medieval Stained Glass*. MA, University of Edinburgh.

GRAVES, C. Pamela, 2002. 'Window Glass'. In: LEWIS, John H., PRINGLE, Denys and CERON-CERRASCO, Ruby (eds.), *Spynie Palace and the Bishops of Moray*. Edinburgh.

HUNTER, John, 2011. 'The Medieval Glass'. In: HODGSON, Georg W. I. (ed.), *Perth High Street: archaeological excavation 1975–1977. Fascicule 4, Living and working in a medieval Scottish burgh: environmental remains and miscellaneous finds*. Perth, 119–125.

KENNEDY, Craig, MURDOCH, Kenneth Robin and KIRK, Susie, 2013. 'Characterisation of Archaeological and in situ Scottish Window Glass', *Archaeometry* 55, 465–478.

KEPPIE, Lawrence J. F. and MURRAY, Frances J., 1981. 'A Roman hypocausted building at Falkirk', *Proceedings of the Society of Antiquaries of Scotland* 111, 248–262.

KUISMA-KURSULA, Pirkko and RAISANEN, Jyrki, 1999. 'Scanning Electron Microscopy – Energy Dispersive Spectrometry and Proton Induced X-ray emission analyses of Medieval glass from Koroinen (Finland)', *Archaeometry* 41, 71–79.

KUNICKI-GOLDFINGER, Jerzy. J., FREESTONE, Ian C, McDONALD, Iain, HOBOT, Jan. A, GILDERDALE-SCOTT, Heather and AYERS, Tim, 2014. 'Technology, Production and Chronology of Red Window Glass in the Medieval period – Rediscovery of a Lost Technology', *Journal of Archaeological Science* 41, 89–105.

LANE, Alan and CAMPBELL, Ewan, 2000. *Dunadd: An Early Dalriadic Capital*. Oxford.

LONGWORTH, Geoffrey, TENNENT, Norman H., TRICKER, Michael J. and VAISHNAVA, Prem P., 1982. 'Iron-57 Mössbauer spectral studies of medieval stained glass', *Journal of Archaeological Science* 9, 261–273.

MCCORMICK, Finbar, 1994. 'Excavations at Pluscarden Priory, Murray', *Proceedings of the Society of Antiquaries of Scotland* 124, 391–432.

MITCHELL, Keith L., MURDOCH, Kenneth Robin and WARD, John R., 2001. *Excavation Report "Fast Castle Excavations 1971–86"*. Edinburgh.

MURDOCH, Kenneth Robin, 2008. 'The Glass'. In: DRANSART, Penny and TRIGG, Jonathan (eds.), *The Bishop's Palace: Fetternear 2005–2006*. Lampeter, 41–55.

- MURDOCH, Kenneth Robin 2013. *Elgin Cathedral Glass*. s. l.
- MURDOCH, Kenneth Robin 2015. *Glass Report: Cromarty Excavations*. s. l.
- PEAKE, James R. N. and FREESTONE, Ian. C., 2011. 'Opaque Yellow Glass production in the Early Medieval period: New evidence'. In: KELLER, Daniel, PRICE, Jennifer and JACKSON, Caroline M. (eds.), *Neighbours and Successors of Rome: Traditions of glass production and use in Europe and the Middle East in the later 1st Millennium AD*. York, 15–21.
- RAURET, Gemma, CASASSAS, Enric, RIUS, F. Xavier and MUÑOZ, M., 1987. 'Cluster analysis applied to spectrochemical data of European Mediaeval stained glasses', *Archaeometry* 29, 240–249.
- REID, Alison G., 1988. *Pitmiddie Village and Elcho Nunnery*. Dundee.
- SPENCER, Helen, KENNEDY, Craig, MURDOCH, Kenneth Robin, FORSTER, Alan and BUCKMAN, Jim, forthcoming. 'Compositional analysis by p-XRF and SEM-EDX of medieval window glass from Elgin Cathedral, Northern Scotland', *Archaeometry*.
- SPICER, Andrew, 2003. Iconoclasm and Adaptation: The Reformation of the Churches in Scotland and the Netherlands. In: GAIMSTER, David and GILCHRIST, Roberta (eds.), *The Archaeology of Reformation 1480–1580*. Leeds, 29–43.
- SPITZER-ARONSON, Martha, 1986. 'Analytical and historical research on medieval multi-layered copper red glass'. In: MANIATIS, Yannis (ed.), *Archaeometry '86: proceedings of the 25th International Symposium*. Athens, 671–676.
- TENNENT, Norman H., MCKENNA, P., LO, K. K., MACLEAN, G. and OTTAWAY, John M., 1984. 'Major, minor and Trace Element analysis of Medieval Stained Glass by Flame Atomic Absorption Spectrometry'. In: LAMBERT, Joseph B. (ed.), *Archaeological Chemistry III*. Washington DC.
- THOMAS, Gordon D., 1988. 'Excavations at the Roman Civil settlement at Inveresk, 1976–77', *Proceedings of the Society of Antiquaries of Scotland* 118, 139–176.
- TURNBULL, Jill 2001. *The Scottish Glass Industry 1610–1750: "To Serve the Whole Nation with Glass"*. Edinburgh.
- WEDEPOHL, Karl Hans and SIMON, Klaus, 2010. 'The Chemical composition of Medieval Wood Ash Glass from Central Europe', *Chemie der Erde – Geochemistry* 70, 89–97.
- WILLMOTT, Hugh and WELHAM, Kate, 2013. 'Late Seventh Century Glassmaking at Glastonbury Abbey', *Journal of Glass Studies*, 55.

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